Water Pollution / Equipment for water pollution control (9)

Dehydration of sludge from waste water treatment with centrifugal separator

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Japan Environmental Management Association for Industry
(JEMAI)

CONTENT

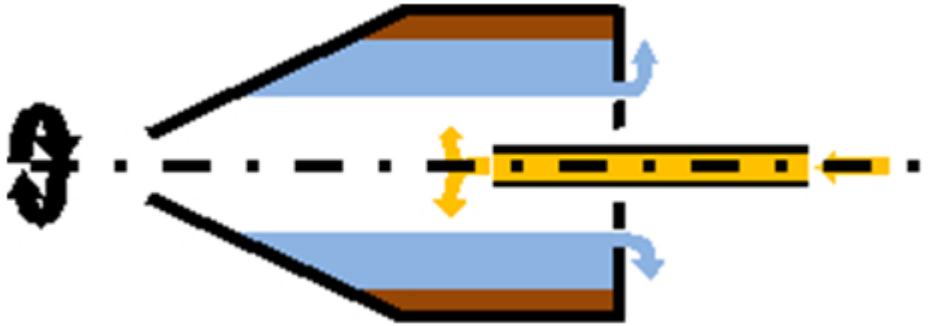
1. Structure of a centrifugal separator (decanter)

1. 1 Kinds of solid-liquid separation

(1) Solid-liquid separation by spontaneous sedimentation

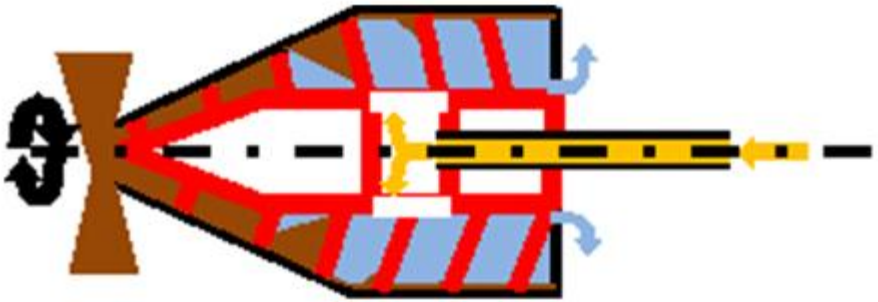
(2) Centrifugal separation

Centrifugal force
2000～3000 times of gravity
Solid content
Accumulate in vessel



(3) Centrifugal separation ＋ Screw

Continuously scrape out solid content from bowl by the difference of rotation speed between screw and of rotating axis.



1．2　Structure of decanter

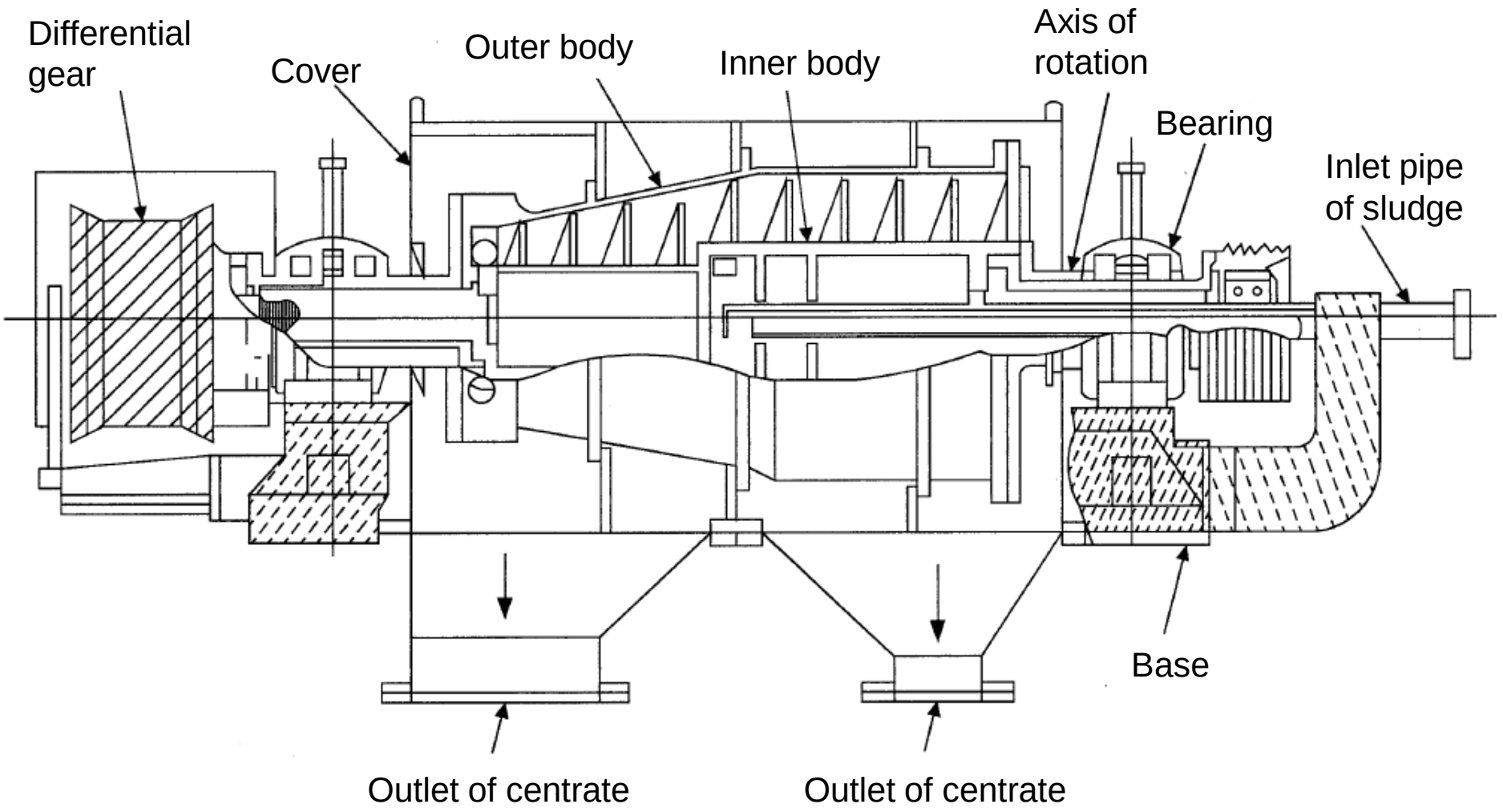
- One of horizontal type centrifugal separator.
- Equipment which separates solid and liquid by centrifugal force.
- Rotating drum consisted of cylinder body and conical part and screw installed in rotating drum are rotating together by differential rate so that centrifugal separation proceeds by centrifugal force.
- Solid of large specific gravity in feed liquor which is supplied from inlet located at center of rotating drum accumulates on inner wall of rotating drum by centrifugal force.

  →rotation number　2000～4000 rpm (= min^{-1})

  centrifugal effect　2000～3000 times of gravity
- Solid accumulated on inner wall of rotating drum is discharged from conical part, where is dewatering zone, to outside of drum with screw.
- Feature

  Solid is dewatered to some extent and discharged.

  High solid content up to 60 wt% is available.
- High concentration of suspended solid in separated water is weak point of decanter but along with progress of polymer coagulant in some examples 99% recovery of solid is achieved.



Horizontal decanter (cross-sectional view)

1．3　Improvement of grouting

Low water content type centrifugal separator
（JIS standard specification：two kinds of liquors grouting centrifugal separator）

(1) Background

Content of water in dewatered sludge is about 80% in general. Therefore more effective dewatering method is required to reduce transportation cost and amount to be treated.

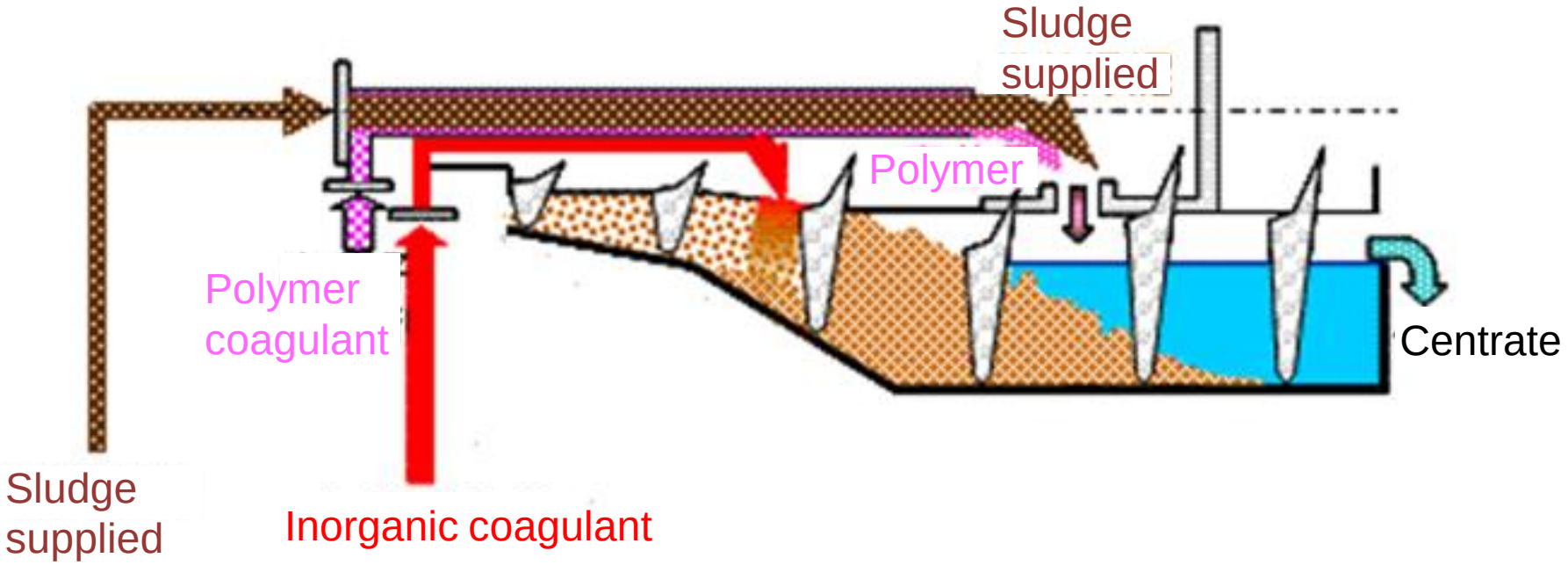
(2) Outline of technology

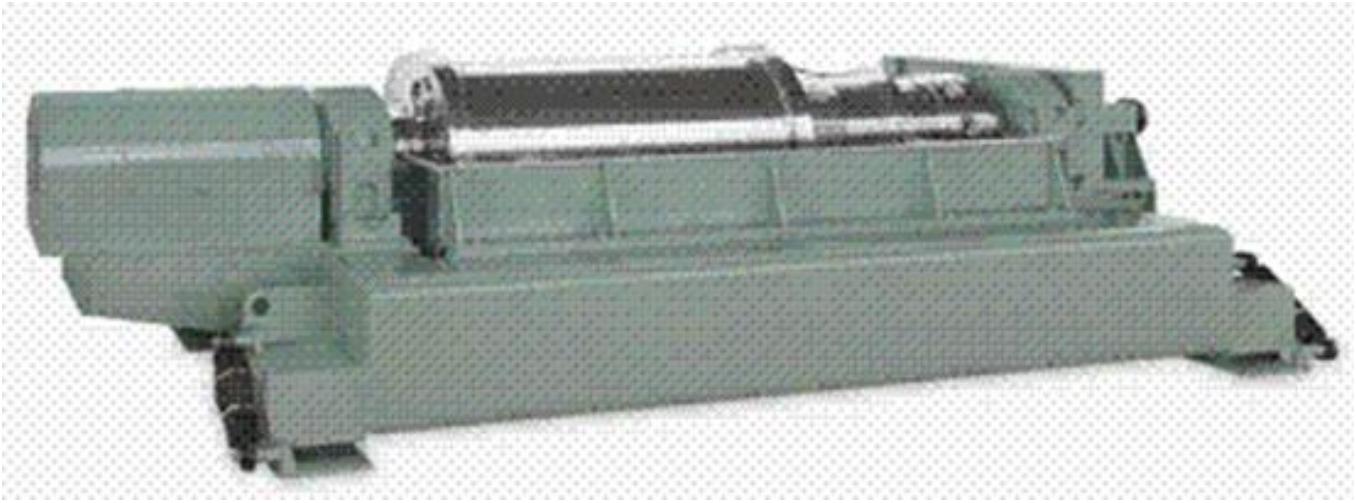
At first polymer coagulant is added at inlet of centrifugal separator and after proceeding dehydration to some extent polyferric sulphate solution is introduced. The water content reduces 6～8% compared with existing dehydrator.

(3) Advantage of introduction

Nitrified sludge is available which is known as difficult dewaterbility. This process can be possible to be introduced to existing dehydrator. About 25% of dumping amount of sludge is reduced because of reducing water content in sludge.

Polyferric sulphate solution can reduce offensive smell of sludge.


Sludge supplied
Polymer
Polymer coagulant
Centrate
Sludge supplied
Inorganic coagulant

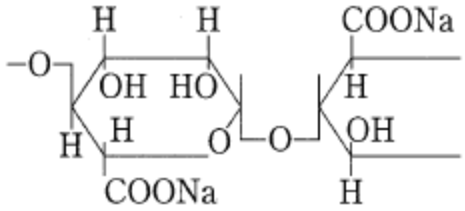
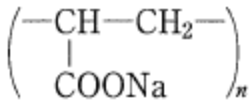
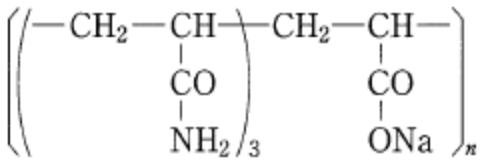
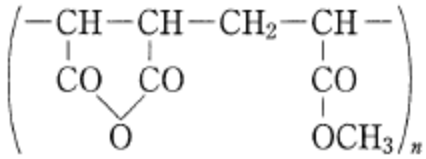


1．4　Kinds of coagulant

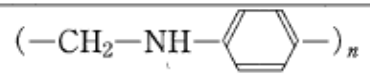
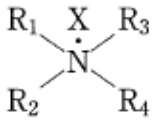
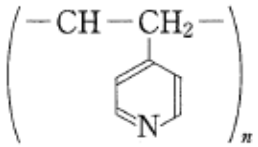
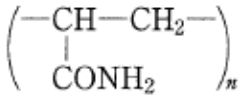
Types and feature of inorganic coagulants

	Chemical name	Chemical formula	pH	Available to drinking water	Comments
Aluminum	Aluminum sulfate	$Al_2(SO_4)_3 \cdot 18H_2O$	6 ～ 8	○	Most popular, in some case with iron salt, called Alum or Aluminium sulphate Alum is said to enhance coagulation effect. Effective to remove chromaticity components and to keep pH stable.
	Sodium aluminates	$NaAlO_2$		○	
	Basic aluminum chloride	$Al_n(OH)_mCl_{3n-m}$ Polymer		○	
Iron	Iron sulphates（Ⅱ）	$FeSO_4 \cdot 7H_2O$	9 ～ 11	○	In case of bad operation condition, remained iron component colors treated water.
	Iron chloride（Ⅲ）	$FeCl_3 \cdot 6H_2O$		○	
	Iron sulphates（Ⅲ）	$Fe_2(SO_4)_3 \cdot nH_2O$		○	
	Iron polysilica	$Fe_2(SO_4)_3 \cdot FeCl_3$		○	
	copperas chloride	$(SiO_2)_n \cdot (Fe_2O_3)$		○	

Polymer coagulant（1/2）

	Chemical name	Chemical formula	pH	Available to drinking water	Comments
Anionic polymer	Sodium alginate		6 or more	○	Cross linking by adsorption. Avoid excess use.
	CMC sodium salt	cellulose $-OCH_2 \cdot COONa$		○	CMC: Carboxymethylcellulose
	Sodium polyacrylate				
	Partially hydrolysis salt of polyacrylamide				
	Maleicacid copolymer	Example 			

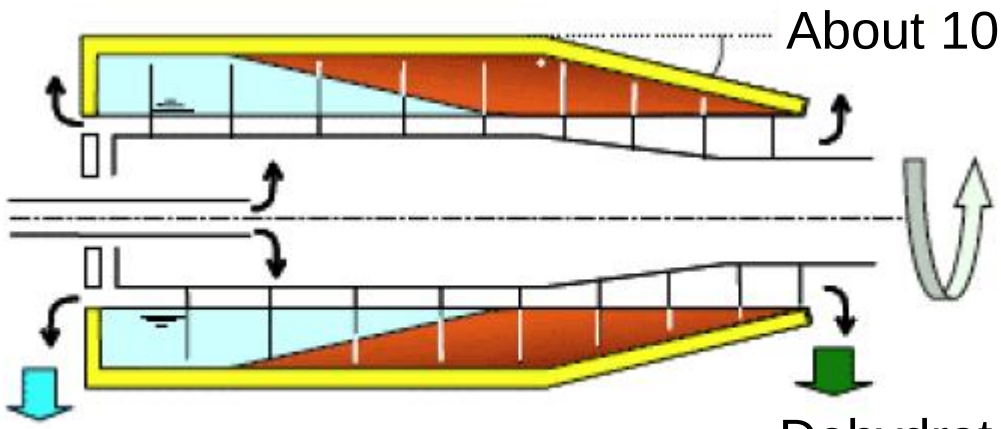
Polymer coagulant（2/2）

	Chemical name	Chemical formula	pH	Available to drinking water	Comments
Cationic polymer	Water-soluble aniline resin		Some types can be used at acid conditi-on.		In some cases this may work as main reagent by itself for negative colloid.
	Polythiourea	$(-R-NHCSNH-)_n$			
	Polyethyleneimine	$(-CH_2CH_2NH)_n$			
	Quaternaty ammonium compounds				
	Polyvinylpyridines				
Non-ionic polymer	Polyacrylamide		Available except too strong acid or alkaline condition. 8 or more	○	Low cost and large effect as coagulant for fine particls of ore and Mg(OH)2
	Polyoxyethylene	$(-CH_2 \cdot CH_2O-)_n$			
	Causticized starch				

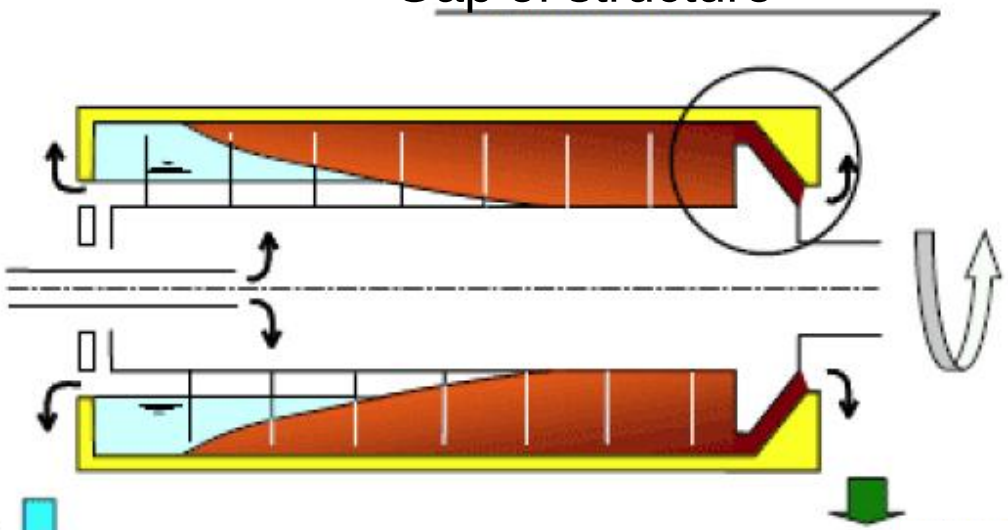
2. Several types of decanter and their performance

2. 1 Types of decanter

Decanter type



Cylindrical type



2．2　Feature of cylindrical decanter

① Cylindrical type of bowl
- Lots of sludge can be preserved in vessel.
- Long retention time of sludge
- Thick layer of sludge can be formed which is effective for dehydration.

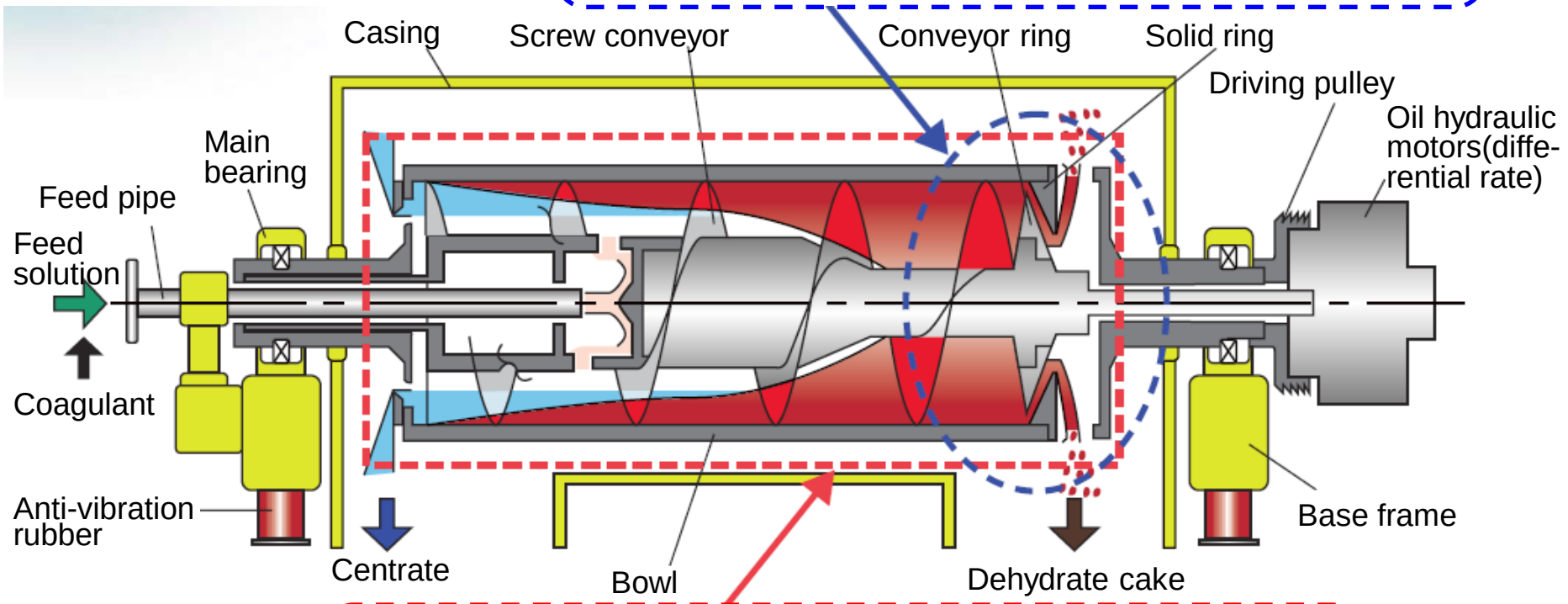
② Gap of structure exists at outlet of dehydrated sludge.
- Because of drastic change of area of cross section at outlet of dehydrated sludge, Discharge resistance becomes large.
- Consequently whole space of bowl near outlet of cake is filled with sludge completely and dehydration of sludge proceeds with strong compress force working to sludge.

③ Only low water content cake can be discharged.
- The sludge which precipitated near to the wall of bow received stronger compressed force then becomes lower content of water. In case of Cylindrical type of bowl only dehydrated cake with maximum centrifugal force is pushed into gap of structure to outlet then only low water content of cake can be discharged.

2．3　Performance of cylindrical decanter

Example：Cylindrical centrifugal dehydrator
（Mitsubishi Heavy Industries Ltd.：MAP Ⅱ）

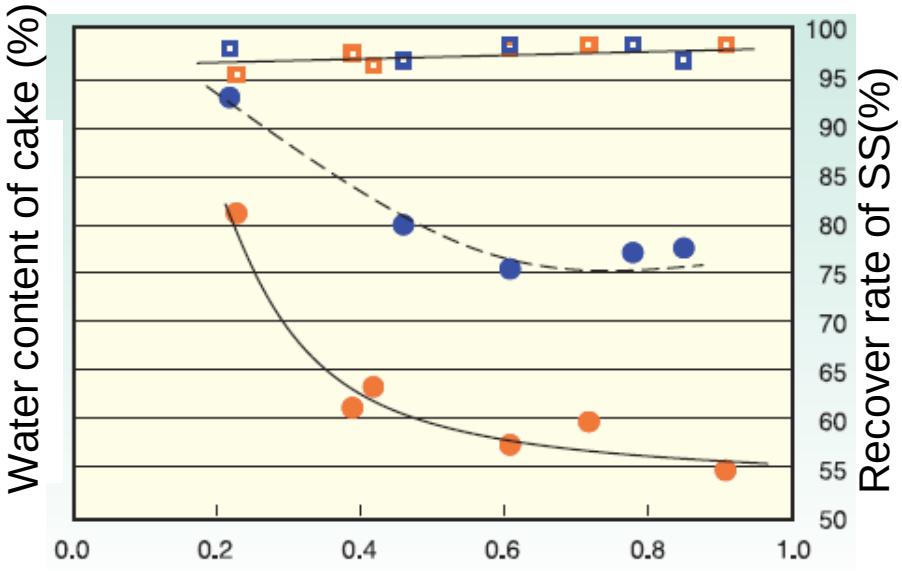
Restricting elements:
- Solid ring + Conveyor ring
- High consolidation effect
- Discharge the highest centrifugally dehydrated cake



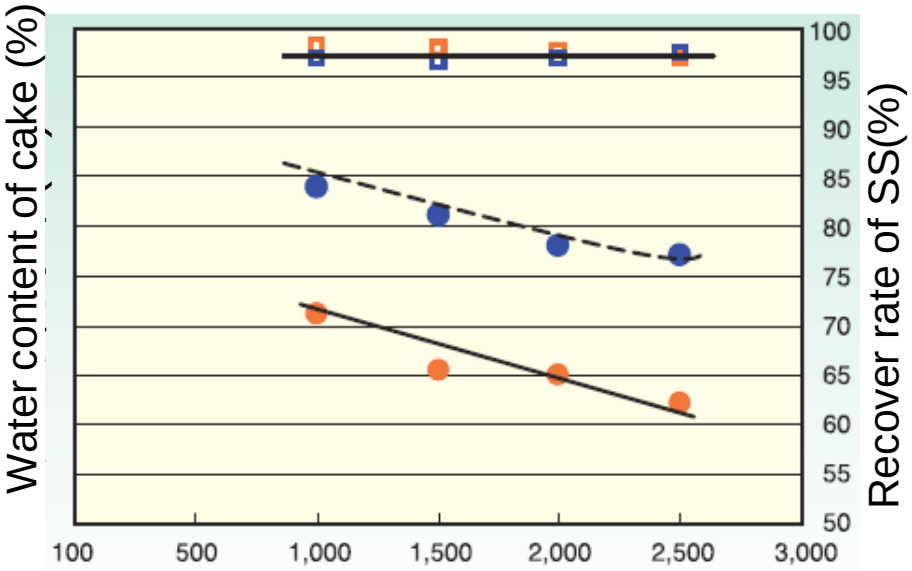
Cylindrical type bowl:
- Make bowl small because of increasing volumetric efficiency.
- Maximum use of centrifugal force.

Actual result

Relationship between Dosage of chemicals and water content and recovery rate of SS



Relationship between centrifugal force and water content and recovery rate of SS



- MAP Ⅱ water content
- Existing type water content
- MAP Ⅱ recovery rate of SS
- Existing type recovery rate of SS

Summary of comparative experiment by pilot machine

Item	Sludge	Result
Water content of cake (Water content of Cylindrical type to decanter)	Mixed sludge	7～8 pt Down
	Digested sludge	3～4 pt Down
	OD sludge	2.5～3 pt Down
Dosage of chemicals (Dosage of Cylindrical type to get same water content of cake as decanter)	Mixed sludge	40～50% of decanter
	Digested sludge	30～60% of decanter
	OD sludge	50～60% of decanter
Centrifugal force (Centrifugal force of Cylindrical type to get same water content of cake as decanter)	Mixed sludge	about 1500G Down
	Digested sludge	about 1000G Down
	OD sludge	500～800G Down

OD : oxidation ditch (method)

Experimental data of pilot machine for one year (Mixed sludge)